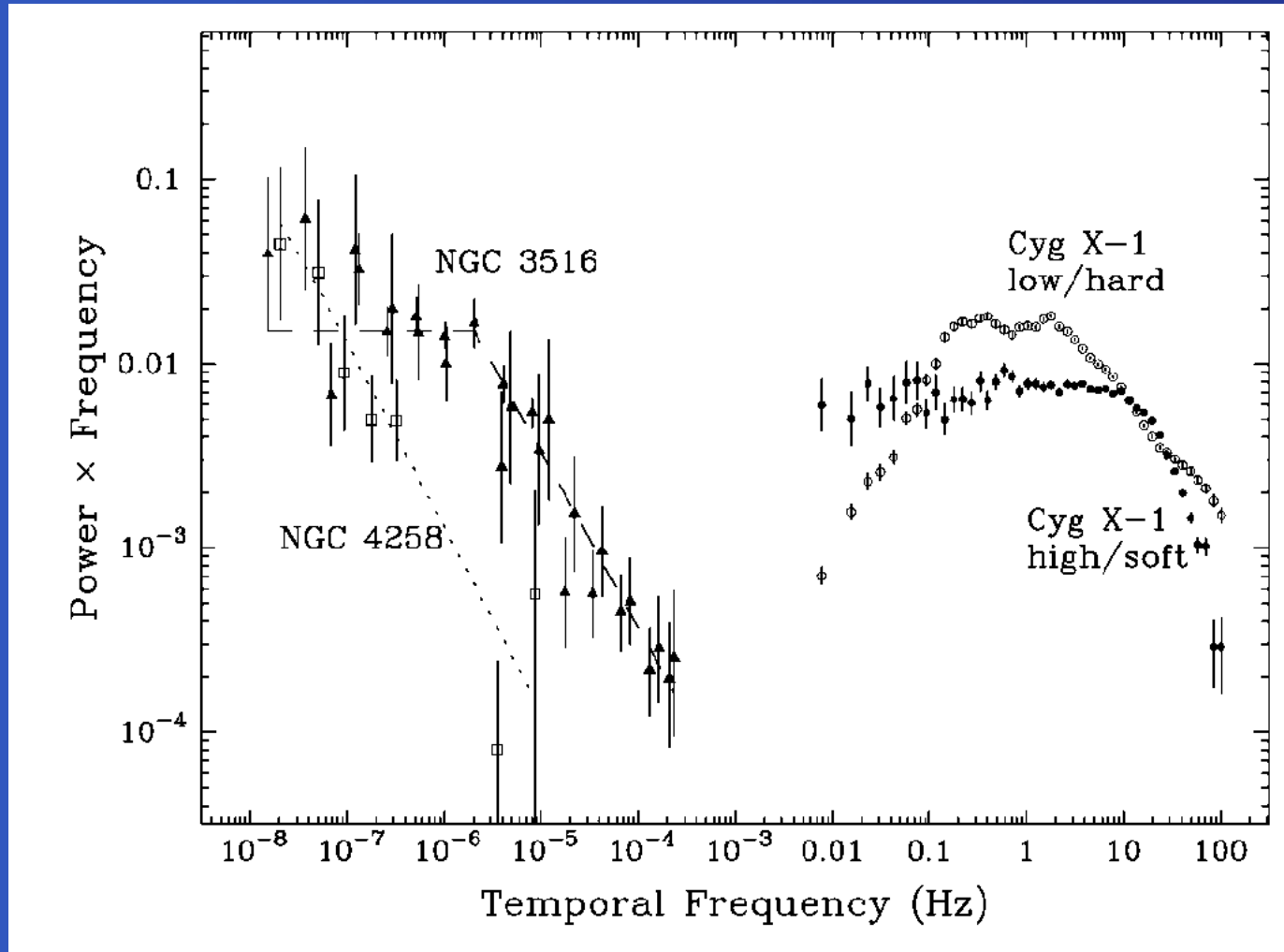


Variability of Black Hole Accretion discs

Michael Mayer & J.E. Pringle

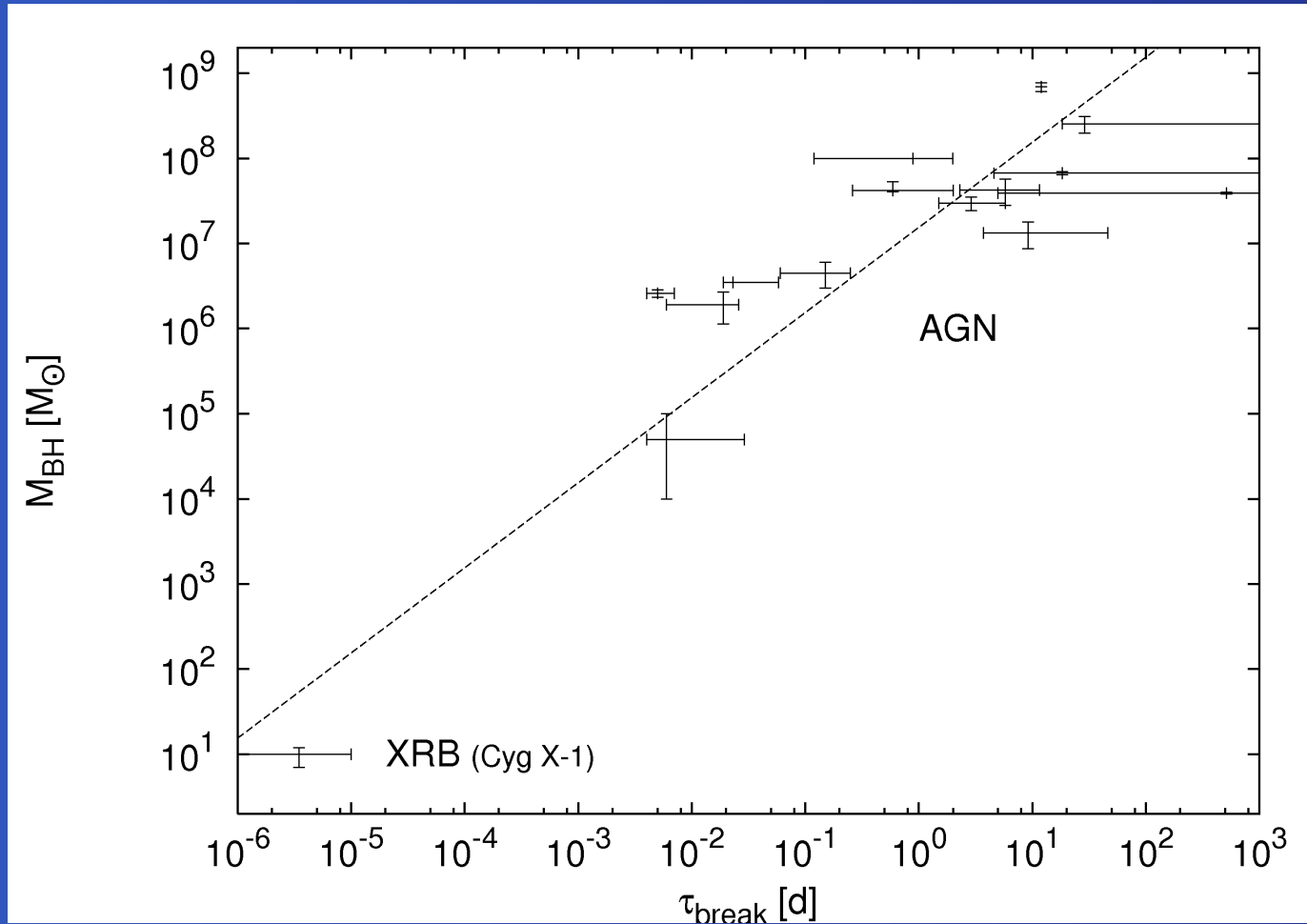
Institute of Astronomy
Cambridge

Timing from AGN and XRB 1/2



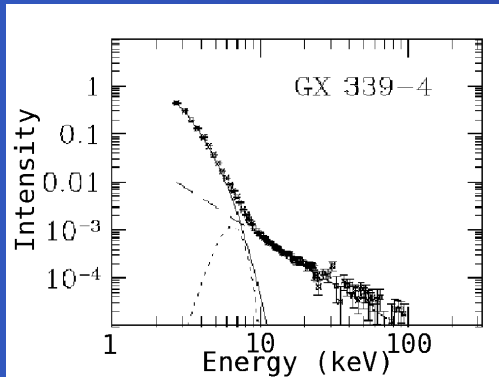
from Markowitz & Uttley (2005)

Timing from AGN and XRB 2/2

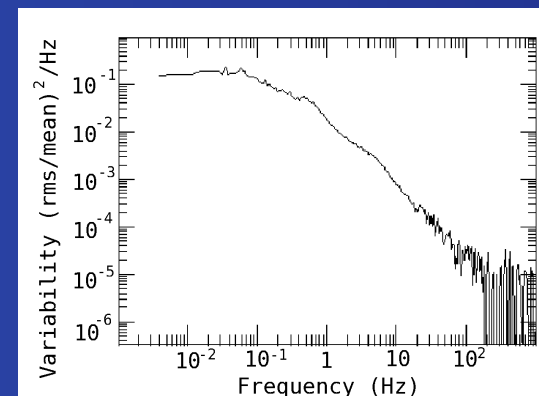
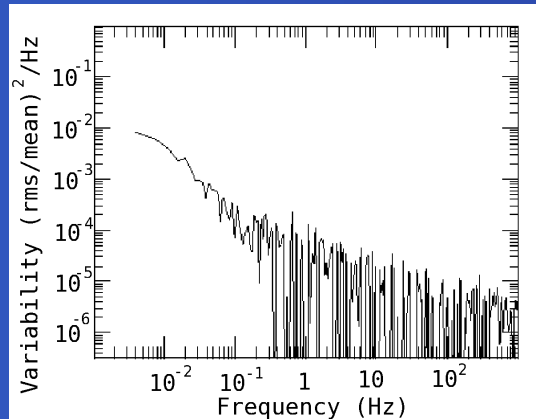
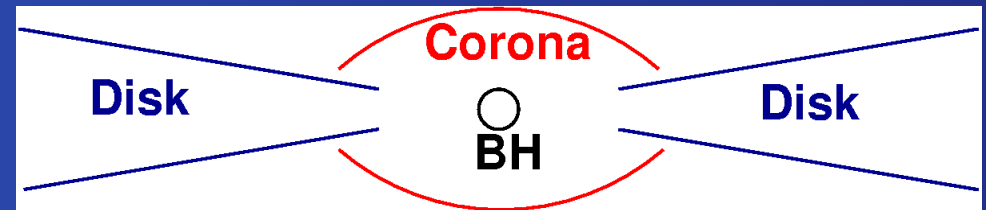
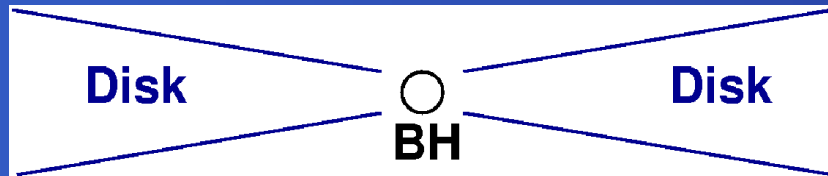
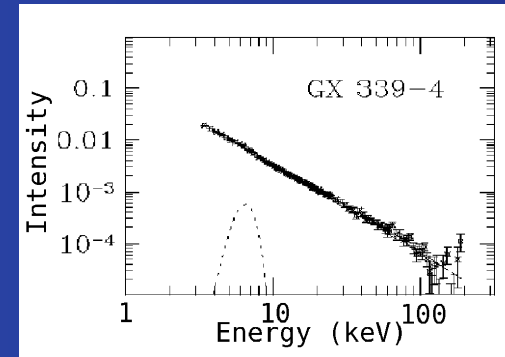


Connection to structure and spectrum

high/soft state



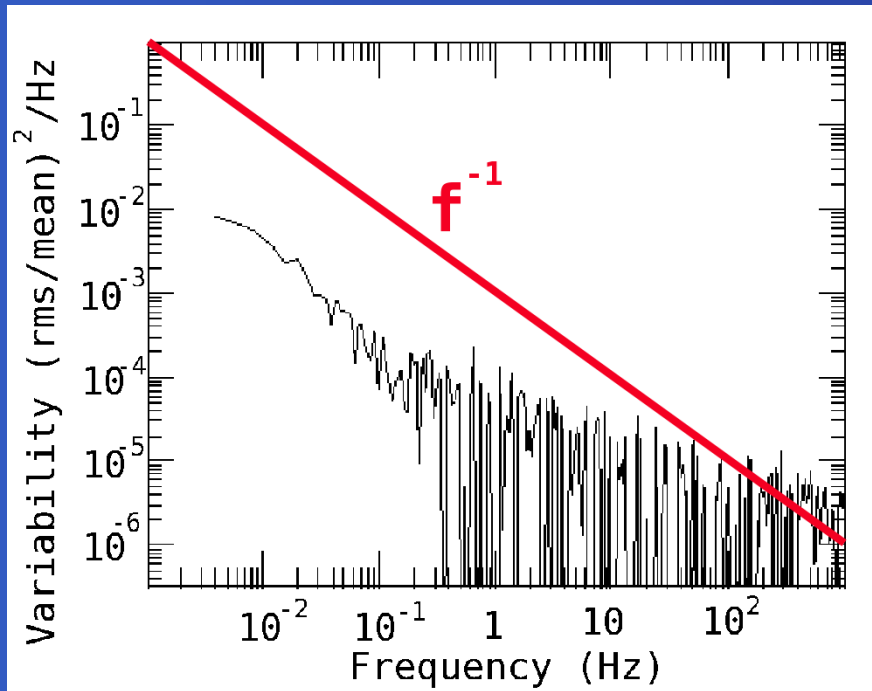
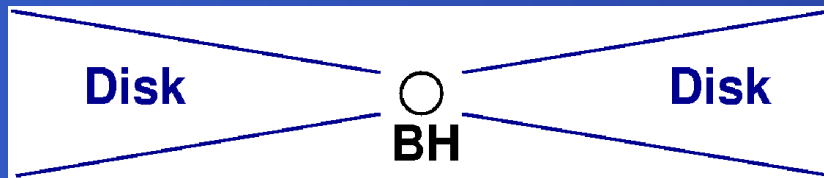
low/hard state



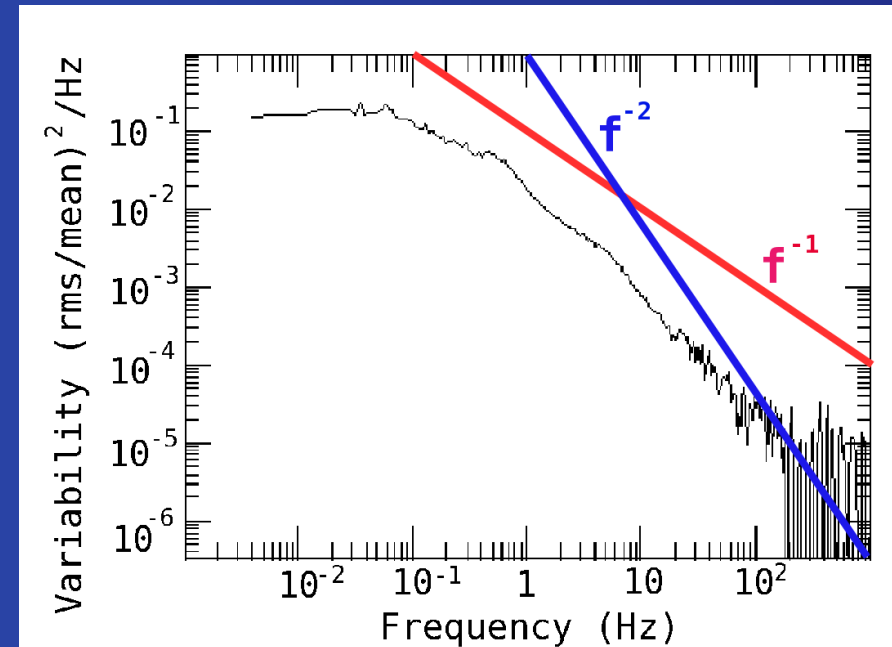
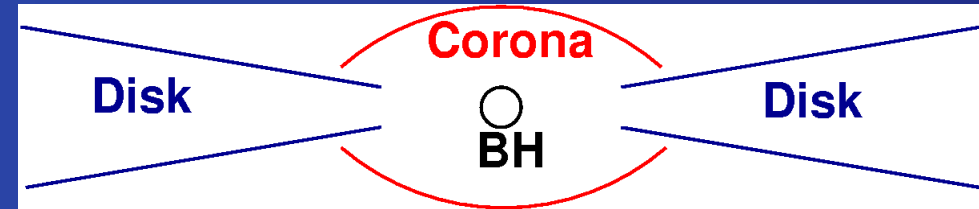
Spectra and PDS from McClintock et al. (2003)

Connection to structure and spectrum

high/soft state

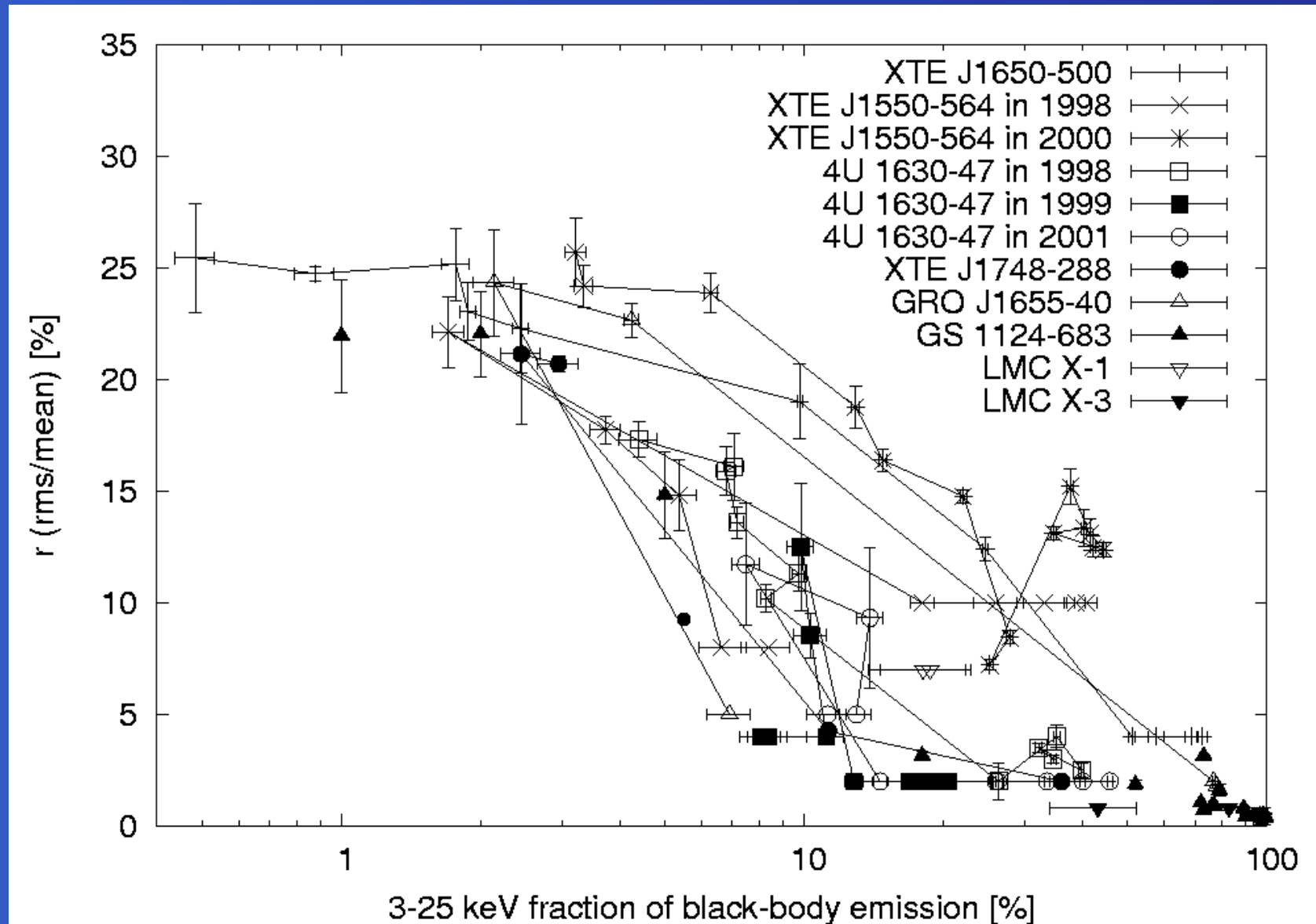


low/hard state



PDS from McClintock et al. (2003)

Variability



Data from Kalemci et al. (2004), Miyamoto et al. (1994), Nowak et al. (2001)

The Problem

$$R = 3R_S$$

$$R = 500R_S$$

dynamical timescale

$$\tau_d = \frac{1}{\Omega_K} = 0.4 \text{ ms} \quad \tau_d = 0.5 \text{ s}$$

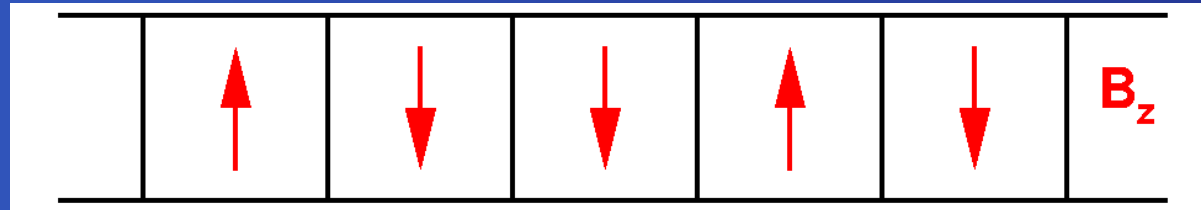
Luminosity

$$L_3/L_{500} \approx 200$$

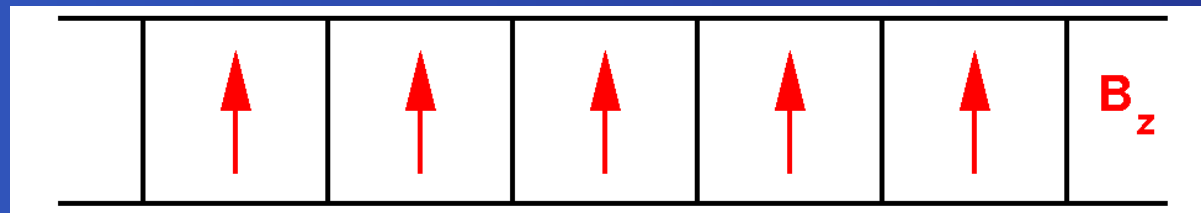
- Never get amplitude and timescale of flickering right at the same time
- Flickering in outer disc is dispersed on the viscous timescale $\tau_v \gg \tau_d \implies$ No flickering visible

The solution: King et al. (2004)

- magnetic dynamos acting in grid cells of width H
- poloidal magnetic field ($B_z \ll 4\pi\alpha P$) changes on about the dynamical timescale
- Most of the time



- Sometimes

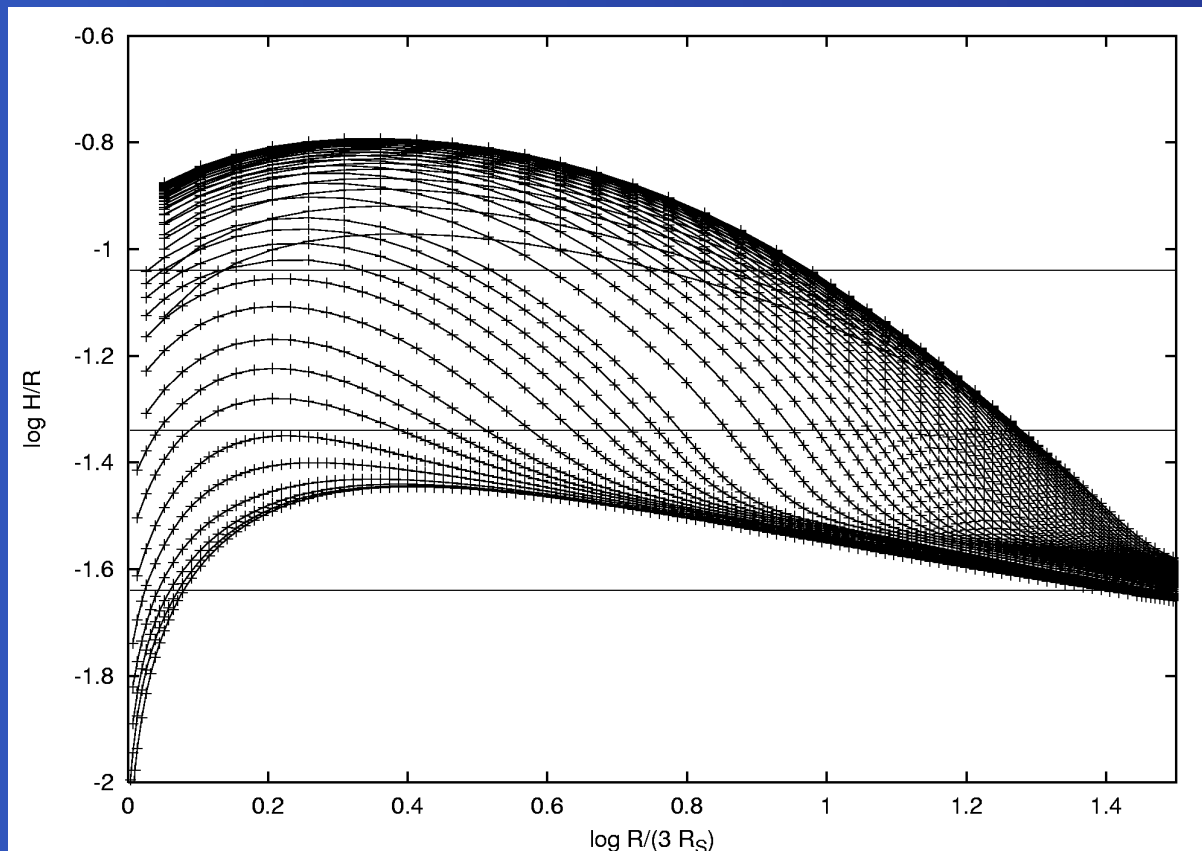


- Alignment and viscous timescale

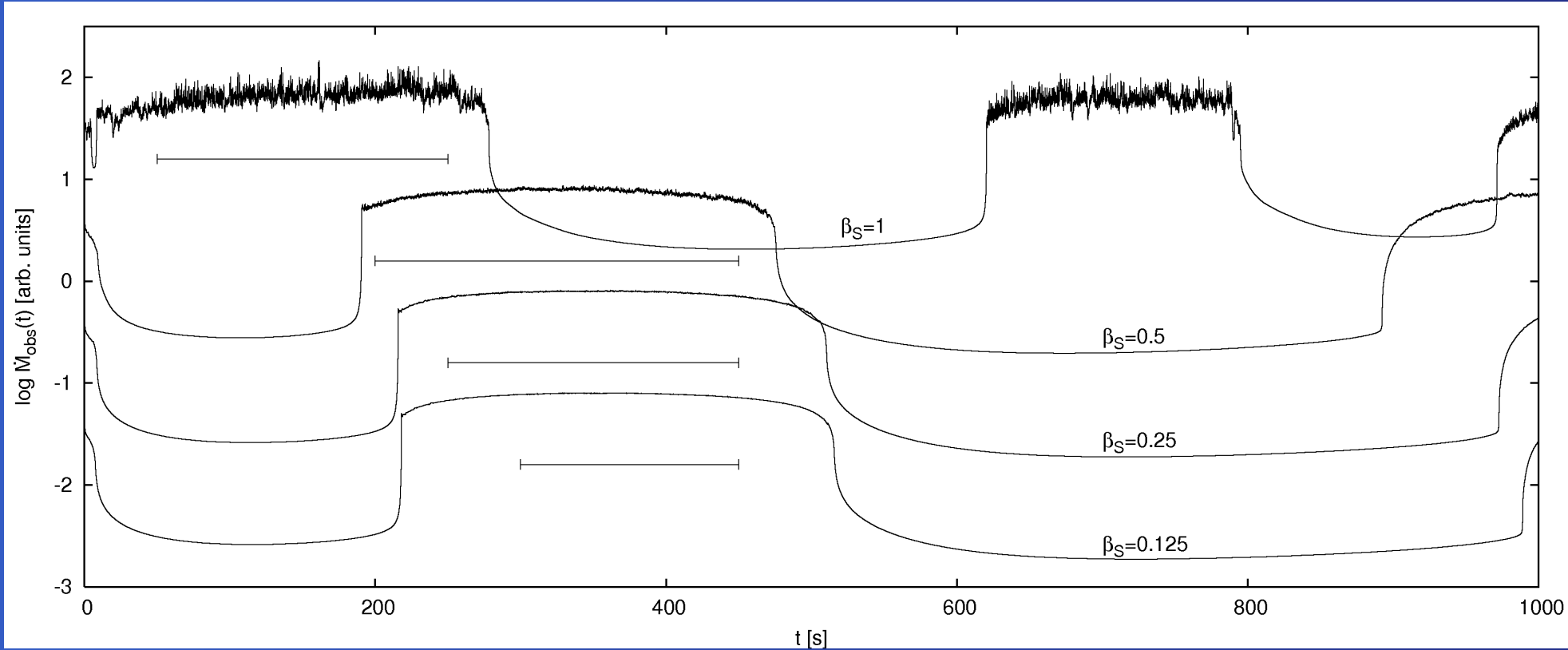
$$\tau_{\text{mag}} \propto 2^{R/H} \tau_d \quad \tau_v \propto (R/H)^2 \tau_d$$

1D model

- one-zone approximation
- time-dependent viscous and thermal evolution
- self-adaptive grid (scale height \approx grid cell width)



Results: Lightcurves

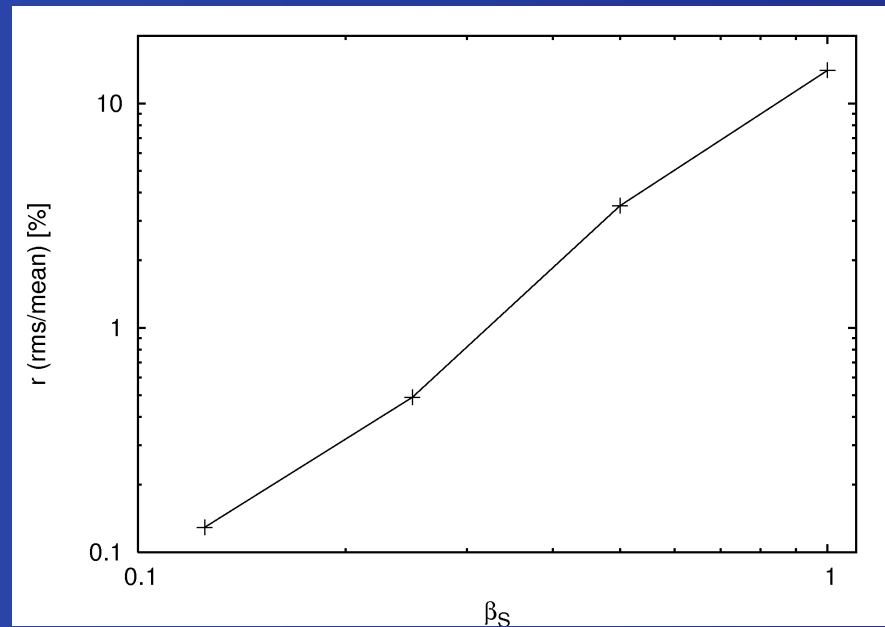
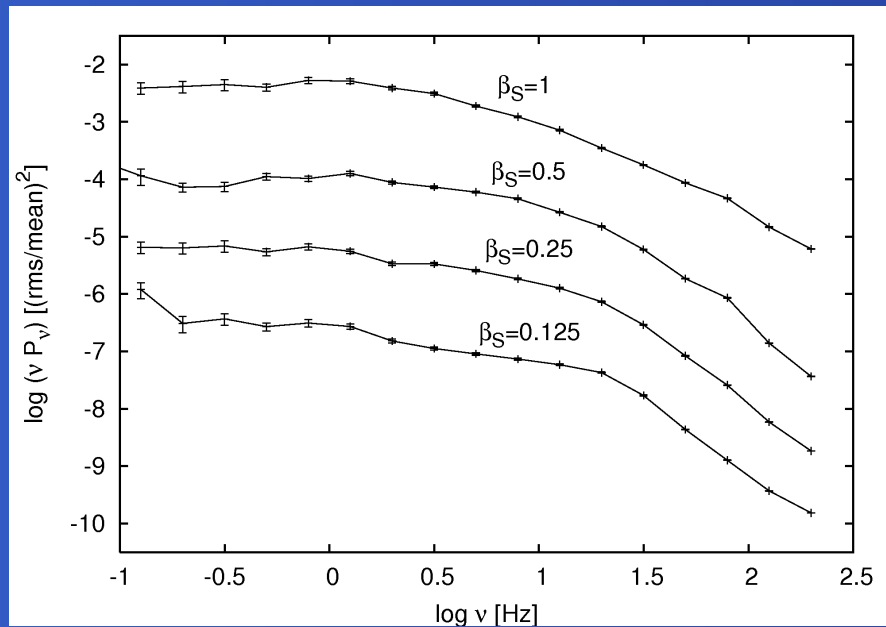


$10 M_{\odot}$ black hole, $\dot{M} = 0.5 \dot{M}_{\text{Edd}}$, $\alpha = 0.1$, $R_A/R = 3$

$$\alpha = \frac{B_{\text{disc}}^2}{4\pi P}$$

$$\beta_S = \frac{B_{z,\text{max}}}{B_{\text{disc}}}$$

Results: Power density spectra



10 M_{\odot} black hole, $\dot{M} = 0.5\dot{M}_{\text{Edd}}$, $\alpha = 0.1$, $R_A/R = 3$

$$\alpha = \frac{B_{disc}^2}{4\pi P}$$

$$\beta_S = \frac{B_{z,max}}{B_{disc}}$$

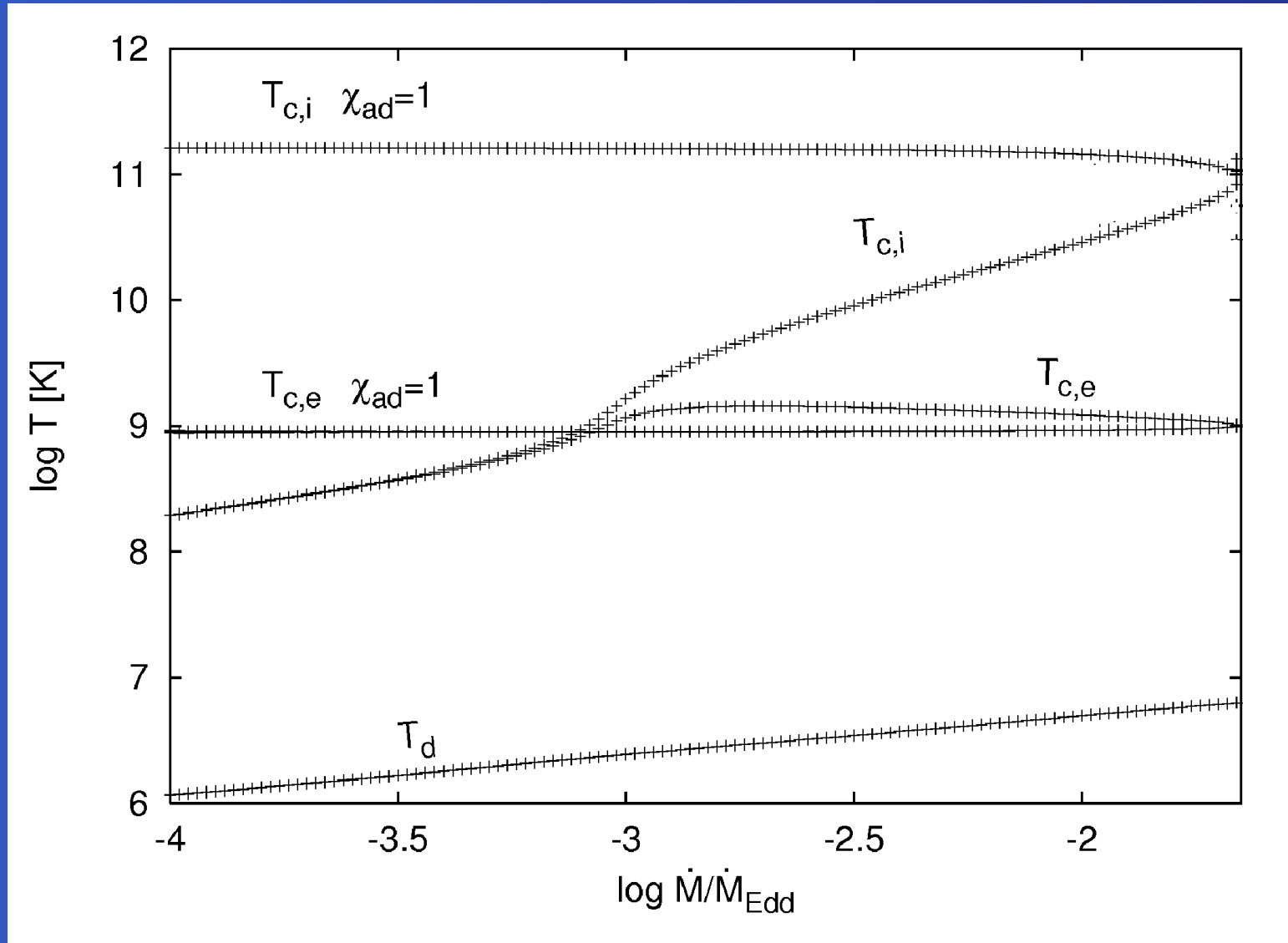
Conclusions

- Extension of the King et al. (2004) model to include detailed disc structure
- Constrain parameter $\beta_s \leq 0.25$ to account for observational results
- Shape and normalisation of the power spectra can be reproduced, i.e. timescales and amplitudes
- The only physical model reproducing rms-flux relation and bicoherence
- Further details in Mayer & Pringle (2006)

Outlook

- Time-dependent two-phase accretion disc (corona+disc)
- Use sandwich geometry
- Exchange of energy/mass between corona and disc
- Model of the low/hard state
- Combine with the flickering

Stationary solutions



$$M=10 M_{\odot}, f_c = \dot{M}_c/\dot{M} = 0.1, R = 30R_S, \alpha = 0.1$$